PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : H01Q 19/09, 15/14, 3/24, 1/38

A1

(11) International Publication Number: WO 94/28595

(43) International Publication Date: 8 December 1994 (08.12.94)

(21) International Application Number: PCT/AU94/00261

(22) International Filing Date: 20 May 1994 (20.05.94)

(30) Priority Data:
PL 9043 27 May 1993 (27.05.93) AU

(71) Applicant *(for all designated States except US)*: GRIFFITH UNIVERSITY [AU/AU]; Kessels Road, Nathan, QLD 4111 (AU).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: THIEL, David, Victor [AU/AU]; 16 Baroona Street, Rochedale, QLD 4123 (AU). O'KEEFE, Steven, Gregory [AU/AU]; 74-78 Shiels Road, Chambers Flat, QLD 4133 (AU). LU, Jun, Wei [AU/AU]; 12 Cummin Street, Wishart, QLD 4122 (AU).

(74) Agent: SPRUSON & FERGUSON; G.P.O. Box 3898, Sydney, NSW 2001 (AU).

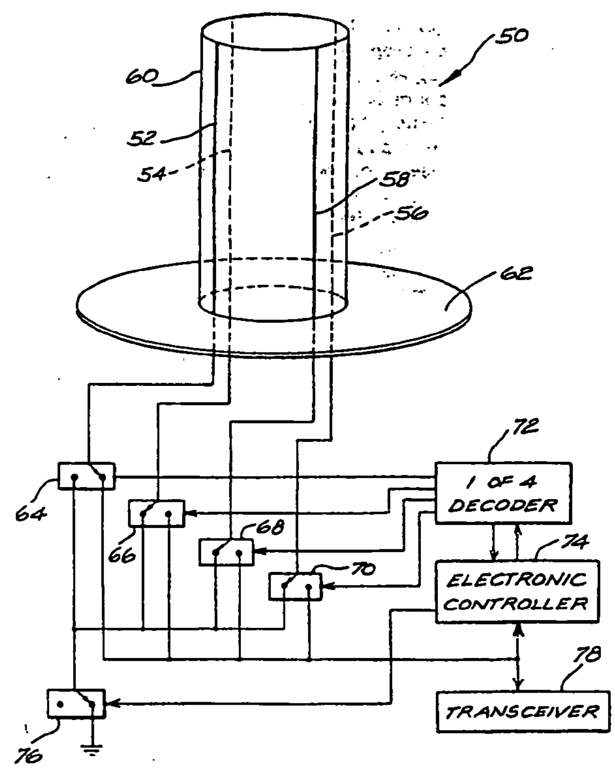
(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, ES, FI, GB, GE, HU, JP, KG, KP, KR, KZ, LK, LU, LV, MD, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.
With amended claims.

(54) Title: ANTENNAS FOR USE IN PORTABLE COMMUNICATIONS DEVICES

(57) Abstract

Antenna arrangements for use with portable communications devices are described. In one embodiment, an antenna (50) has four equally spaced monopole elements (52-58) mounted in a regular array on the outer surface of a solid cylinder structure (60). The cylindre (60) has a high dielectric constant, and extends from a conductive ground plane (62). The monopole elements (52-58) can be switched by switching elements (64-70, 76) so that one or more is active, with the others acting as parasitic directors/reflectors being connected commonly to ground or left in an open circuit condition to be effectively transparent. A shielded single monopole antenna (10) is also described.



ANTENNAS FOR USE IN PORTABLE COMMUNICATIONS DEVICES

Technical Field

This invention relates to antenna arrangements for use in portable communications devices. Embodiments thereof specifically relate to physically small antennas, directional antennas, and to electronically steerable antennas.

Portable or hand-held communications devices are to be taken to include cellular mobile telephones, radio pagers and two-way radios (walkie-talkies). Other applications for antennas embodying the invention are to be found in geophysical (such as ground probing radar and borehole tomography) and other radar systems (such as anti-collision radar for moving vehicles).

Description of the Prior Art

Antennas are used in a wide variety of applications both as transmitters and receivers of electromagnetic energy. In many of these applications it is desirable to maximise the directivity of the antenna. In the prior art this has been achieved by techniques such as the use of reflector screens (e.g. parabolic dish antennas, corner reflectors), reflector elements (e.g. curtain arrays, Yagi parasitic elements), slow wave structures (e.g. Yagi antennas) and multiple antenna arrays.

By way of a specific example, in mobile cellular telecommunications it is desirable to improve the directivity of the antenna of a mobile handset for reason of reducing the power consumption, hence lessening demand on the battery. Improved directivity also has benefit in increasing the range of mobile cellular

telephones in relation to a cell site, and in reducing the interference between adjacent cells.

There also presently are concerns about the safety of mobile cellular telephones on users. Human tissue is a very good conductor of electricity, even at high frequencies, and it has been suggested that brain tumors may occur with prolonged use of such devices for reason of the antenna being very close to the user's skull resulting in very high strength electromagnetic fields concentrated about the antenna penetrating the skull and damaging brain tissue. The IEEE has published Technical Standard No. C95.3 in relation to recommend maximum exposure to electromagnetic radiation received by, and propogated from, antennae. A directional antenna tends to minimise the radiation directed towards the user, and from this point of view is most desirable.

Shielding too is an established technique to reduce exposure. There is a trade-off, however, in that the proximity of a shield to an antenna can adversely affect the efficiency of the antenna. As a rule of thumb, a shield must be located at least 1/4 wavelength away from the antenna.

In other applications, such as geophysical systems, severe deep fading caused by multipath interference occurs when two signals are incident on the same antenna with approximately equivalent field strengths and with approximately 180° phase difference. A steerable directional antenna can minimise the effect of such fading.

An example of an antenna structure that has consideration of the issues of directivity and steerability is that disclosed in U.S. Patent No. 4,700,197 issued to Robert Milne.

Size too is an important consideration, particularly as

electronic communications devices become ever more miniaturized. To some extent the reduction of the size of antennas is antagonistic to achieving improved directivity. In free space, the distance between radiating elements/reflectors is a substantial part of one free space wavelength of the radiation in air. This means the antennas may be relatively large in more than one direction if directionality is required. Large antenna installations also are undesirable for reasons of appearance and mechanical stability.

Disclosure of the Invention

The invention, in one aspect, is directed to an antenna which is directional and also compact.

Therefore, the invention discloses a compact directional antenna arrangement comprising:

a spaced parallel array of antenna elements carried by a dielectric structure, the antenna elements being electrically connected to respective switching means, and the antenna arrangement being operable by the respective switching means to selectively switch one or more of the antenna elements to be active.

Preferably, the non-active radiating elements are switched by respective switching means to be either electrically connected to ground or in an open circuit condition. The driven elements can be monopoles or dipoles. An active monopole element can be physically sized to be resonant such that the reactive component of the antenna impedance is approximately zero.

Preferably, the antenna further comprises an earth plane arranged to be perpendicularly mounted to an end of the dielectric structure.

Preferably, the dielectric structure is regularly shaped, and

most preferably is a cylinder. The driven elements can be arranged in a regular array.

Preferably, the relative dielectric constant, ε_r, is large. While $\varepsilon_r = 10$ results in a very significant reduction in size, $\varepsilon_r = 100$ is even more advantageous.

The radiating elements can be coupled to transceiver means by the switching means. The switching means can be switchably controlled by control means to selectively cause one or more of the radiating elements to be active in accordance with the direction of strongest received signal strength.

The invention also is directed to an antenna structure to protect the user of a portable communications device from excessive exposure to electromagnetic radiation.

Therefore, the invention further discloses a shielding structure for an antenna of a portable communications device, the structure comprising a sandwiched arrangement of, in order, a conductive sheet, a sheet of dielectric material and an antenna element, the shielded structure being arranged on the communications device so that the conductive sheet is closer to the user's head than the antenna element in use of the communications device.

Preferably, the shielding structure is planar, and the thickness of the dielectric sheet is less than $\lambda/(2\sqrt{\varepsilon_r})$, where ε_r is the relative dielectric constant of the dielectric sheet, and λ is the wavelength of the electromagnetic radiation to be received or transmitted by the antenna element.

The invention is further directed to a directional antenna, and thus discloses an antenna arrangement comprising an elongate antenna element carried by, and arranged to be parallel with the longitudinal

axis of an elongate dielectric material, and in a manner to be eccentrically located with respect to the said longitudinal axis.

In another aspect the invention is directed to a directional and physically small antenna, and therefore further discloses a compact directional antenna arrangement comprising a spaced parallel array of antenna elements carried by a dielectric structure, one or more of the antenna elements being active, and the other antenna elements being passive and commonly connected to ground.

The invention yet further discloses a method of switching an antenna arrangement to achieve improved directionality, the antenna arrangement comprising a spaced parallel array of antenna elements carried by a dielectric structure, the method comprising the steps of:

selectively connecting one or more of the radiating elements by a respective switching means to be active;

measuring received signal strength for each selective connection of radiating elements; and

maintaining the selective connection of the one or more radiating elements for the highest received signal strength.

Preferably, the method further comprises the step of periodically repeating the selective connection, measurement and maintaining steps.

Embodiments of the invention provide an antenna that is more efficient than those in the prior art, since there is a reduction in power consumption of the electronic equipment to which the antenna is coupled (e.g. a cellular telephone). This occurs for reason of there being less absorption by the user's head, increased signal strength due to improved directionality, less cross-polarisation and a minimal change in antenna impedance with the user's head position.

The antenna also will provide increased range, and offers

improved performance under conditions of multi-path fading. There further is an associated health benefit, since the electromagnetic energy absorbed by the user's head is at a lower level than in the prior art.

One other specific advantage is that the antenna can be directly substituted for prior art antennas in portable communications devices. In one example, a physically smaller antenna having improved directivity can be substituted for an existing antenna in a cellular telephone. Thus the telephone casing can further be reduced in size to provide the user with greater portability.

Brief Description of the Drawings

Embodiments of the invention will be described with reference to the accompanying drawings, in which:

Figs. 1a, 1b and 1c show a cellular telephone incorporating a shielded antenna structure;

Fig. 2 shows a perspective view of a directional array antenna incorporating parasitic elements;

Fig. 3 shows a perspective view of a directional array antenna together with connected switching electronics;

Fig. 4 shows a polar pattern for a limiting configuration of the antenna shown in Fig. 3;

Fig. 5 shows a polar pattern for a modified form of the antenna shown in Fig. 3;

Fig. 6 shows a polar pattern for a particular switched arrangement of the antenna shown in Fig. 3;

Fig. 7 shows a polar pattern for another switched arrangement of the antenna shown in Fig. 3; and

Fig. 8 shows a further embodiment relating to ground probing radar.

Best Mode for Carrying Out the Invention

The embodiments will be described with reference to mobile cellular telecommunications. It is to be appreciated, however, that the invention equally is applicable to radio communications in general, including electromagnetic geophysics, radar systems and the like, as noted above.

One method of reducing the influence on reception and transmission performance of an antenna associated with a portable communications device by the user's head is to shield the antenna from the head. In prior art arrangements, however, a conductive sheet acting as a shield cannot be located closer than one quarter-wavelength from an antenna without degrading the efficiency of the antenna.

Figs. 1a, 1b and 1c show a shielded antenna arrangement for a mobile telephone that allows the shield to be physically close to the antenna, contrary to prior art arrangements.

The antenna arrangement is constructed as a composite or sandwiched structure 12, as best shown in the partial cross-sectional view of Fig. 1c. The structure 12 comprises a conductive sheet 22, an intermediate layer of high dielectric constant low loss material 24 and a monopole antenna 14. The conductive sheet 22 typically is constructed of a thin copper sheet, whilst the dielectric material 24 typically is of alumina, which has a relative dielectric constant $\varepsilon_r > 10\ \varepsilon_0$.

The conductive sheet 22 is located closest to the 'user' side of the mobile telephone 10, being the side having the microphone 16,

earspeaker 18 and user controls 20, and therefore shields the user's head in use of the mobile telephone.

The effect of the dielectric material 24 is to allow the conductive back plane 22 to be physically close to the antenna 12 without adversely affecting the antenna's efficiency. By utilising a material with a relative dielectric constant > 10 ε_0, and choosing the thickness of the dielectric material 24 to be < $\lambda/(2\sqrt{\varepsilon_r})$, the 'image' antenna is in phase with the radiating antenna 14 in the direction away from the conductive sheet 22. Thus the structure 12 has the effect of blocking the passage of electromagnetic radiation to the user's head in the vicinity of the antenna 14, and beneficially causing the reflected radiation to act in an additive manner to maximize received or transmitted signals.

The structure 12 can be mechanically arranged either to fold down onto the top of the mobile telephone 10, or to slidingly retract into the body of the telephone 10. The shielding structure also can be shaped as other than a flat plane; for example, it can be curved in the manner of half-cylinder.

Fig. 2 shows an antenna arrangement 30 that can be used in direct substitution for known antenna configurations, for example, in cellular mobile telephones. The antenna 30 has four equally spaced quarter-wavelength monopole elements 32-38 mounted onto the outer surface of a dielectric cylinder 40. Most usually, the cylinder 40 will be solid.

Note also, that a shape other than a cylinder equally can be used. In a similar way, the elements 32-38 need not be regularly arranged. The only practical requirement is that the dielectric structure be contiguous. The elements 32-38 also can be embedded

within the dielectric cylinder 40, or, for a hollow cylinder, mounted on the inside surface. What is important is that there be no air gap between each of the elements and the dielectric cylinder.

Only one of the monopole elements 32 is active for reception and transmission of electromagnetic radiation (RF signals). The other three monopole elements 34-48 are passive/parasitic, and commonly connected to ground. The antenna arrangement 30 exhibits a high degree of directivity in a radially outward direction coincident with the active element 32, with the three parasitic elements tending to act as reflector/directors for incident RF signals, as well as constituting a form of shielding. The scientific principles underpinning these performance benefits will be explained presently, and particularly with respect to the antenna configuration shown in Fig. 3.

The antenna 30 is suitable for use with mobile cellular telephones as noted above, and can be incorporated wholly within the casing of conventional mobile telephones. This is possible due to the antenna's reduced physical size (with respect to the prior art), and also permits direct substitution for conventional antenna configurations.

Size is an important design consideration in cellular telephones. A long single wire antenna (for example, an end feed dipole or a 3/4 wavelength dipole antenna) distributes the RF energy so that head absorption by the user is reduced. The antenna also is more efficient due to a larger effective aperture. The longer the antenna is, however, the less desirable it is from the point of view of portability and mechanical stability. The antenna shown in Fig. 2 can achieve the same performance characteristics as the noted larger known types of antenna, but has the added advantage of being physically small.

The antenna arrangement 50 shown in Fig. 3 has four equally spaced quarter-wavelength monopole elements 62-68 mounted on the outer surface of a solid dielectric cylinder 60. The monopoles 62-68 again can be embedded in the dielectric cylinder's surface, or the dielectric structure can be formed as a hollow cylinder and the monopole elements mounted to the inner surface thereof, although such an arrangement will have lower directivity since the relative dielectric constant of 1.0 of the air core will reduce the overall dielectric constant.

The cylinder 60 is constructed of material having a high dielectric constant and low loss tangent such as alumina which has a relative dielectric constant $\varepsilon_r > 10\varepsilon_0$.

The monopoles 52-58 form the vertices of a square, viz., are in a regular array, and oriented perpendicularly from a circular conductive ground plane 62. The monopoles 52-58 lie close to the centre of the ground plane 62. The ground plane is not essential to operation of the antenna 50, but when present serves to reduce the length of the monopole elements.

A conductor embedded in a dielectric material has an electrical length reduced by a factor proportional to the square root of the dielectric constant of the material. For a conductor lying on the surface of an infinite dielectric halfspace with a relative dielectric constant ε_r, the effective dielectric constant, ε_{eff}, is given by the expression: $\varepsilon_{eff} = (1+\varepsilon_r)/2$.

If the conductor lies on the surface of a dielectric cylinder and parallel to its axis, and there are other conductive elements parallel to it, the effective dielectric constant is modified still further. Factors which influence the effective dielectric constant include the cylinder's radius, and the number and proximity of the additional

elements.

In the case of a relative dielectric constant, $\varepsilon_r = 100$, the length of the monopoles 52-58 can physically be reduced by the factor of approximately seven when the cylinder diameter is greater than 0.5 free space wavelengths. For example, for an antenna operating at 1 GHz, a quarter wavelength monopole in free air has a physical length of about 7.5 cm, however, if lying on the surface of a dielectric cylinder with $\varepsilon_r = 100$, the monopole can be reduced in physical size to about 1.1 cm.

Each of the monopoles 52-58 respectively is connected to a solid state switch 64-70. The switches are under the control of an electronic controller 74 and a 1-of-4 decoder 72 that together switch the respective monopoles. One of the monopoles 52 is switched to be active, whilst the rest of the monopoles 54-58 are switched to be commonly connected to ground by their respective switches 66-70 and the master switch 76. This, in effect, is the configuration shown in Fig. 2. The master switch 76 has a second switched state which, when activated, results in the non-active monopoles being short-circuited together without being connected to ground. In this configuration, the passive monopoles 54-58 act as parasitic reflector elements, and the antenna 50 exhibits a directional nature.

Directivity is achieved for a number of reasons. A conductor located some distance from the centre of a dielectric cylinder, yet still within the cylinder, has an asymmetrical radiation pattern. Further, passive conductors of a dimension close to a resonant length and located within one wavelength of an active element act as reflectors, influence the radiation pattern of the antenna and decrease its resonant length.

By appropriate changes in the length of monopole antennas, the input impedance and the directionality of the antenna 50 can be controlled. For example, for a two element antenna with one element active and the other element shorted to ground, for the smallest resonant length (i.e. when the reactance of the antenna is zero), the H plane polar pattern is similar to a figure of eight, providing the dielectric cylinder's radius is small. For antenna lengths marginally greater than this value, the front to back ratio (directivity) increases significantly.

In another configuration (not specifically shown), the passive monopoles 54-58 can be left in an open circuit condition. This effectively removes their contribution from the antenna (i.e. they become transparent). In this configuration, the antenna is less directional than if the monopoles 54-58 were shorted to ground (or even simply shorted altogether), however the antenna still provides significant directionality due to the dielectric material alone.

The dielectric cylinder 60 also increases the effective electrical separation distance. This is advantageous in terms of separating an active element from an adjacent passive element, which, if short circuited to ground, tends to degrade the power transfer performance of the antenna. Therefore, the effective electrical separation distance between the active monopole 52 and the diametrically opposed passive monopole 56 is given by $d/(\varepsilon_r)^{0.5}$, where d is equal to the diameter of the dielectric cylinder 60. The effective electrical separation distance between the active monopole 52 and the other passive monopoles 54,58 is given by $d/(2\varepsilon_r)^{0.5}$.

The dielectric cylinder 60 also has the effect of reducing the effective electrical length of the monopoles. This means that the

mechanical dimensions of the antenna are smaller for any operational frequency than conventionally is the case; the electrical length and separation therefore are longer than the mechanical dimensions suggest. For an operational frequency of around 1 GHz, the size of the monopoles and dielectric cylinder are typically of length 1.5 cm and diameter of 2 cm respectively.

The antenna 50 shown in Fig. 3 also has the capability of being electronically steerable. By selecting which of the monopoles 52-58 is active, four possible orientations of a directional antenna can be obtained.

The steerability of the antenna 50 can be utilised in mobile cellular telecommunications to achieve the most appropriate directional orientation of the antenna with respect to the present broadcast cell site. The electronic controller 74 activates each monopole 52-58 in sequence, and the switching configuration resulting in the maximum received signal strength is retained in transmission/reception operation until, sometime later, another scanning sequence is performed to determine whether a more appropriate orientation is available. This has the advantage of conserving battery lifetime and ensuring maximum quality of reception and transmission. It may also reduce the exposure of a user of a mobile telephone to high energy electromagnetic radiation.

The sequenced switching of the monopoles 52-58 can be done very quickly in analogue cellular telephone communications, and otherwise can be part of the normal switching operation in digital telephony. That is, the switching would occur rapidly enough to be unnoticeable in the course of use of a mobile telephone for either voice or data.

Examples of theoretical and experimental results for a number of antenna arrangements now will be described.

Arrangement A

Fig. 4 shows an experimental polar plot of an eccentrically insulated monopole antenna. This is a configuration having a single conductor eccentrically embedded in a material having a high dielectric constant. It could, for example, be constituted by the antenna of Fig. 2 without the three grounded parasitic conductors 34-38. The radial axis is given in units of dB, and the circumferential units are in degrees.

The RF signal frequency is 1.6 GHz, with a diameter for the dielectric cylinder of 25.4 mm and a length of 45 mm. The relative dielectric constant is 3.7. As is apparent, the front-to-back ratio (directivity) of the antenna is approximately 10 dB.

Arrangement B

This arrangement utilises a simplified antenna structure over that shown in Fig. 2. The antenna has two diametrically opposed monopole elements (one active, one shorted to ground) on an alumina dielectric cylinder ($\varepsilon_r = 10$) having a diameter of 12 mm. The length of each monopole is 17 mm for the first resonance.

Fig. 5 shows both the theoretical and experimental polar patterns at 1.9 GHz for this antenna. The radial units are again in dB. The theoretical plot is represented by the solid line, whilst the experimental plot is represented by the circled points. At this frequency, the antenna has a front to back ratio of 7.3 dB.

Arrangement C

A four element antenna can be modelled using the Numerical Electromagnetics Code (NEC). Fig. 6 shows theoretical NEC polar

results obtained as a function of frequency for a four element cylindrical antenna structure similar to that shown in Fig. 2 (i.e. one active monopole and three passive monopoles shorted to ground). The cylinder diameter is 12 mm, the length of the monopole elements is 17 mm and the relative dielectric constant $\varepsilon_r = 10$.

Note that at 1.6 GHz the antenna is resonant and the polar pattern is a figure of eight shape. For frequencies greater than this, the antenna front-to-back ratio (directivity) becomes larger. This effect also can be induced by increasing the dielectric constant or increasing the diameter of the antenna.

Arrangement D

Fig. 7 shows experimental data at a frequency of 2.0 GHz for a four element antenna having the same dimensions as those noted in respect of Fig. 6, which is in general agreement with the corresponding theoretical plot shown in Fig. 6.

In another application relating to ground probing radar, radar transceivers utilise omnidirectional antennas to receive echoes from objects lying within a 180° arc below the position of the antenna. As a traverse is conducted, each object appears with a characteristic bow wave of echoes resulting from side scatter.

Another embodiment of an antenna configuration particularly suited for use in ground probing radar is shown in Fig. 8. The antenna 90 incorporates four dipole elements 92-98 arranged on, and fixed to, a dielectric cylinder 100. In this instance no conductive ground plane is required.

In the conduct of ground probing radar studies, two directional orientations of the antenna 90 are used. This is achieved by controlled switching between the driven dipole elements 92,96.

Switching is under the control of the electronic controlling device 102 illustrated as a 'black box', which controls the two semiconductor switching elements 94,96 located at the feed to the driven dipole elements 92,96. In operation, either driven dipole 92,96 is switched in turn, with the other remaining either open circuit or short circuited to ground. The passive dipole elements 94,98 act as parasitic reflectors, as previously discussed.

By utilising the two switched orientations of the antenna 90 in conducting ground probing radar measurements, the effects of side scatter can be minimised mathematically with processing. This results in improved usefulness of the technique, and particularly improves in the clarity of an echo image received by reducing the typical bow wave appearance.

Numerous alterations and modifications, as would be apparent to a person skilled in the art, can be made without the departing from the basic inventive concept.

For example, the number of antenna elements is not be restricted to four. Other regular or irregular arrays of monopole or dipole elements, in close relation to a dielectric structure, are contemplated.

CLAIMS:

1. A compact directional antenna arrangement comprising:

a spaced parallel array of antenna elements carried by a dielectric structure, the antenna elements being electrically connected to respective switching means, and the antenna arrangement being operable by the respective switching means to selectively switch one or more of the antenna elements to be active.

2. An antenna arrangement as claimed in claim 1, wherein the non-active antenna elements are switched by respective switching means either to be electrically connected to ground or left in an open circuit condition.

3. An antenna arrangement as claimed in claim 2, wherein the dielectric structure is a cylinder and the antenna elements are mounted to the outside of the cylinder extending parallel to the longitudinal axis of the cylinder.

4. An antenna arrangement as claimed in claim 1, wherein the switching means are selectively controlled by control means to cause one or more of the antenna elements to be active in accordance with the direction of strongest received signal strength.

5. A compact directional antenna arrangement comprising a spaced parallel array of antenna elements carried by a dielectric structure, one or more of the antenna elements being active, and the other antenna elements being passive and commonly connected to ground.

6. A shielding structure for an antenna of a portable communications device, the structure comprising a sandwiched arrangement of, in order, a conductive sheet, a sheet of dielectric material and an antenna element, the shielded structure being arranged on the communications device so that the conductive sheet is closer to the user's head than the antenna element in use of the communications device.

7. A shielding structure as claimed in claim 6, wherein the thickness of the dielectric sheet is less than $\lambda/(2\sqrt{\varepsilon_r})$, where ε_r is the relative dielectric constant of the dielectric sheet, and λ is the wavelength of the electromagnetic radiation to be received or transmitted by the antenna element.

8. A directional antenna arrangement comprising an elongate antenna element carried by, and arranged to be parallel with the longitudinal axis of an elongate dielectric structure and in a manner to be eccentrically located with respect to the said longitudinal axis.

9. A method of switching an antenna arrangement to achieve improved directionality, the antenna arrangement comprising a spaced parallel array of antenna elements carried by a dielectric structure, the method comprising the steps of:

selectively connecting one or more of the radiating elements by a respective switching means to be active;

measuring received signal strength for each selective connection of radiating elements; and

maintaining the selective connection of the one or more radiating elements for the highest received signal strength.

10. A method as claimed in claim 9, comprising the further steps of periodically repeating the selective connection, measurement and maintaining steps.

AMENDED CLAIMS

[received by the International Bureau on 8 November 1994(08.11.94) ; original claims 1-3 amended ; new claims 4-7, 9-11, 13,14, 19 and 23 added ; claims 4, 8, 9, 10, 6 and 7 amended and renumbered as claims 8, 12,15, 16, 17 and 18 respectively (3 pages)]

1. A directional antenna arrangement comprising:

a non-planar array of wire antenna elements located within or on the surface of dielectric structure, the antenna elements being electrically connected to switching means, and the antenna arrangement being operable by the switching means to selectively switch one or more of the antenna elements to be active, the non-switched antenna elements being parasitic.

2. An antenna arrangement as claimed in claim 1, wherein the parasitic antenna elements are switched by said switching means either to be electrically connected to ground or in an open circuit condition.

3. An antenna arrangement as claimed in either one of claim 1 or claim 2, wherein the antenna elements are mounted to the outer surface of the dielectric structure.

4. An antenna arrangement as claimed in claim 3, wherein the antenna elements are arranged in a regular array.

5. An antenna arrangement as claimed in claim 4, wherein the dielectric structure is a cylinder, and the antenna elements extend parallel to the longitudinal axis of the cylinder.

6. An antenna arrangement as claimed in claim 4, wherein the dielectric structure is a rectangular body, and the antenna elements extend parallel to the longitudinal axis of the rectangular body.

7. An antenna arrangement as claimed in either claim 5 or claim 6, wherein the cylinder is either solid or hollow.

8. An antenna arrangement as claimed in claim 3, wherein the switching means are selectively controlled by control means to cause one or more of the antenna elements to be active in accordance with the direction of greatest received signal strength.

9. An antenna arrangement as claimed in claim 3, wherein the relative dielectric constant of the dielectric structure is greater than 10 ε_0, where ε_0 is the permittivity of free space.

10. An antenna arrangement as claimed in claim 9, wherein the antenna elements are separated by a minimum distance of $\frac{\lambda_0}{10} \cdot \frac{1}{\sqrt{\varepsilon_r}}$, where λ_0 is the wavelength in free space of the electromagnetic radiation to be received or transmitted by the antenna elements, and ε_r is the relative permittivity of the dielectric structure.

11. An antenna arrangement as claimed in claim 10, wherein the length of the antenna elements is greater than $\frac{\lambda_0}{5} \cdot \frac{1}{\sqrt{\varepsilon_r}}$.

12. A directional antenna arrangement comprising at least one wire antenna element located within or on the surface of a dielectric structure, the or each antenna element being arranged to be parallel with, and offset from, a longitudinal axis of the dielectric structure.

13. An antenna arrangement as claimed in claim 12, further comprising switching means electrically connected to the or each antenna element, the switching means being controllable to selectively switch an antenna element to be either active or parasitic.

14. An antenna arrangement as claimed in claim 13, wherein the switching means is further controllable to switch the or each parasitic antenna element either to be electrically connected to ground or in an open circuit condition.

15. A method of switching an antenna arrangement to achieve improved directionality, the antenna arrangement comprising a non-planar array of parallel wire antenna elements located within or on the surface of a dielectric structure, the method comprising the steps of:

selectively connecting one or more of the antenna elements by switching means to be active, the non-switched antenna elements being passive;

measuring received signal strength for each selected connection of the one or more antenna elements; and

maintaining the selected connection of the one or more radiating elements for which there is the greatest received signal strength.

16. A method as claimed in claim 15, further comprising periodic repetition of the selective connection, measurement and maintaining steps.

17. A shielding structure for an antenna of a portable communications device, the structure comprising the sandwiched arrangement of a reflective array, a dielectric material and at least one antenna element, the shielding structure being arranged so that the reflective array is closer to a user's head than the antenna element in use of the communications device.

18. A shielding structure as claimed in claim 17, wherein the thickness of the dielectric material is less than $\lambda/(2\sqrt{\varepsilon_r})$.

19. A shielding structure as claimed in claim 17, wherein the reflective array comprises one or more conductive sheets.

20. A shielding structure as claimed in claim 17, wherein said at least one antenna element comprises an array of parallel wire elements, ones of which are active and the others of which are parasitic.

21. A shielding structure as claimed in claim 20, wherein said wire elements are electrically connected to switching means to selectively switch said wire elements to be active or parasitic.

22. A shielding structure as claimed in claim 17 and that is planar.

23. A shielding structure as claimed in claim 17 and that is formed as a half cylinder.

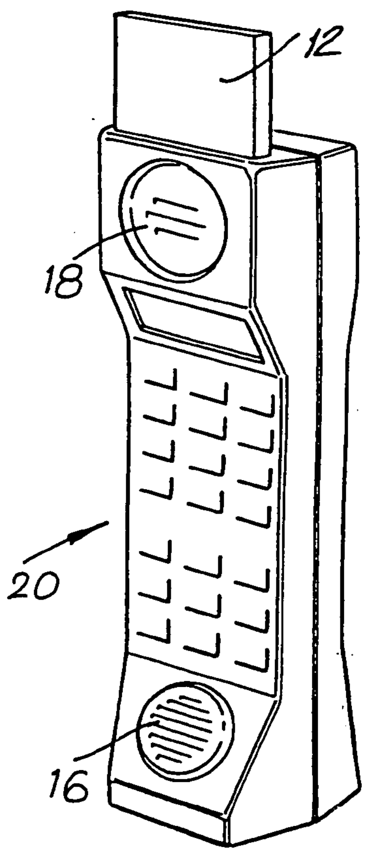


FIG. 1a

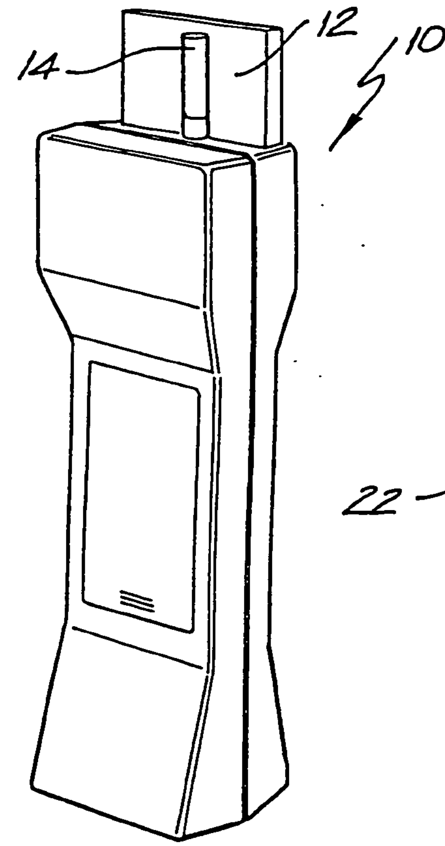


FIG. 1b

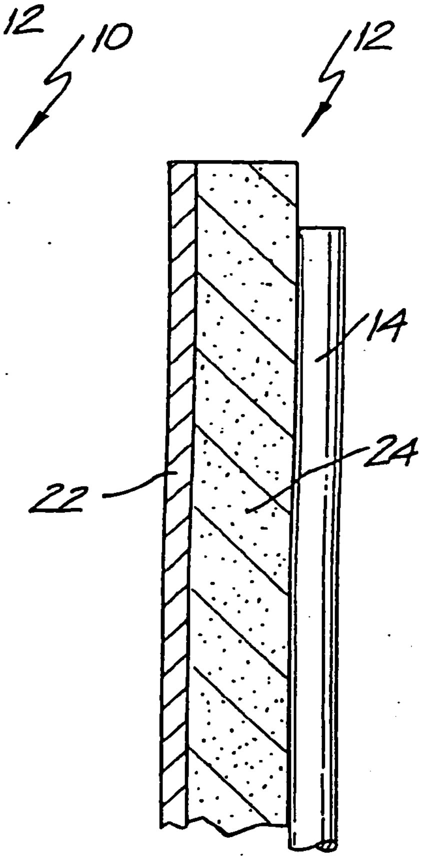


FIG. 1c

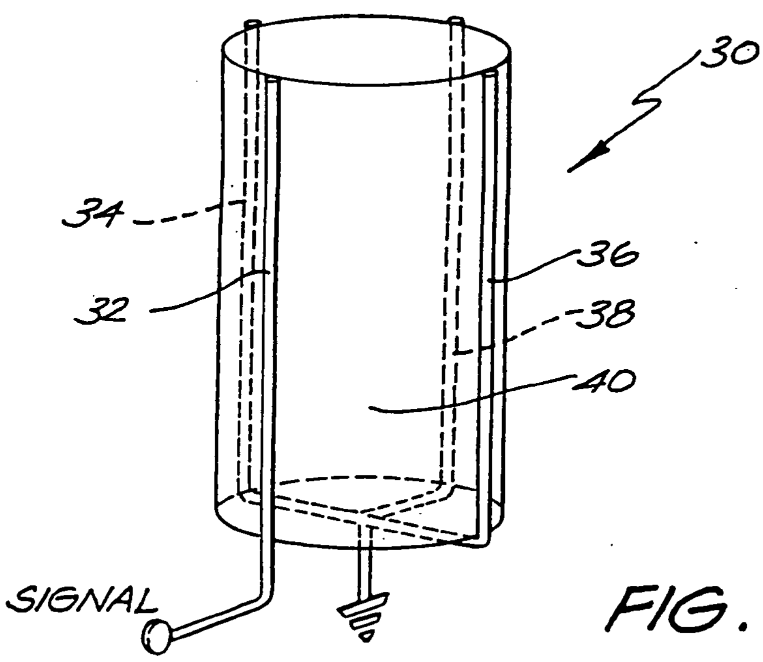


FIG. 2

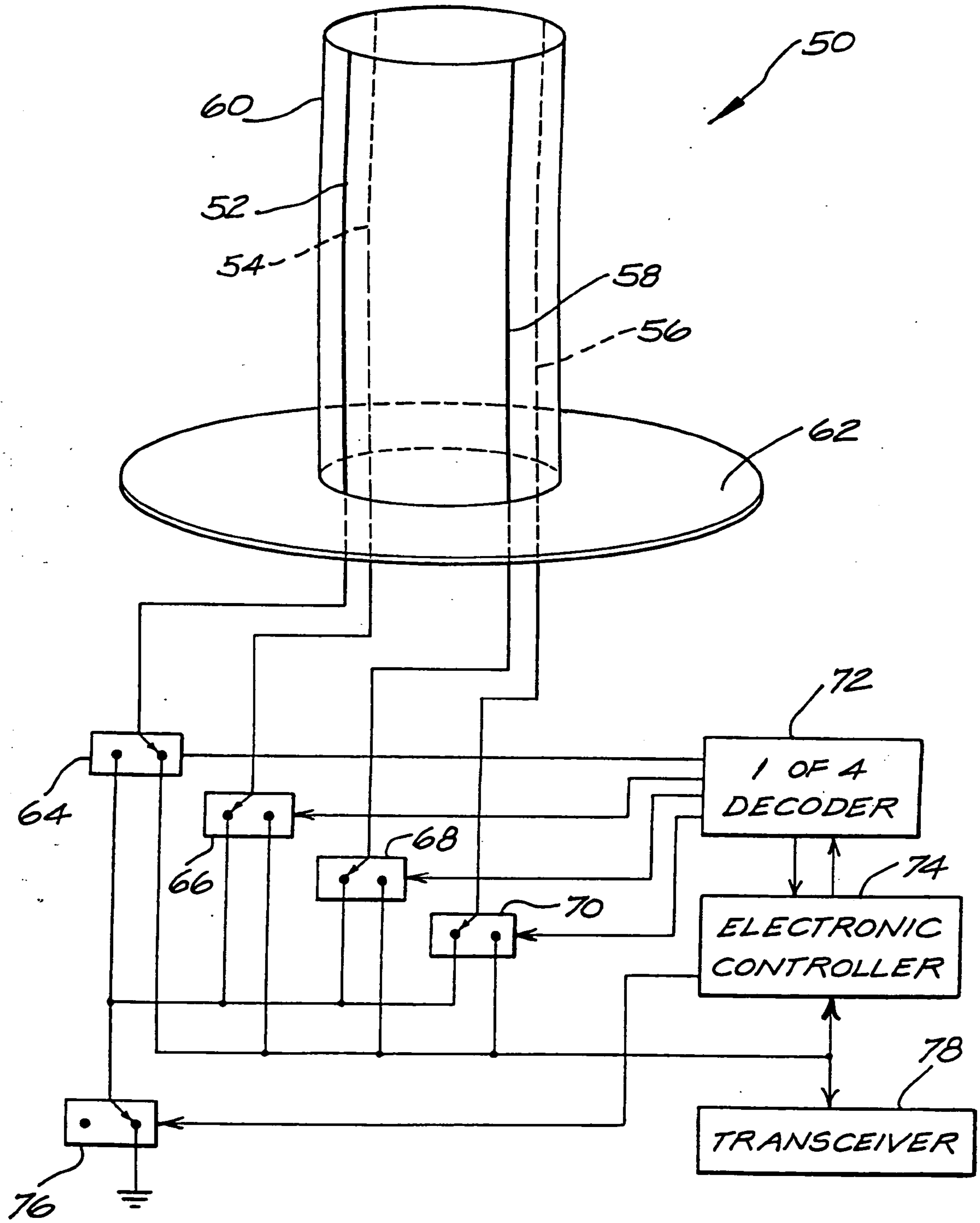

50
60
52
54
58
56
62
72
1 OF 4 DECODER
64
66
68
70
74
ELECTRONIC CONTROLLER
78
TRANSCEIVER
76

FIG. 3

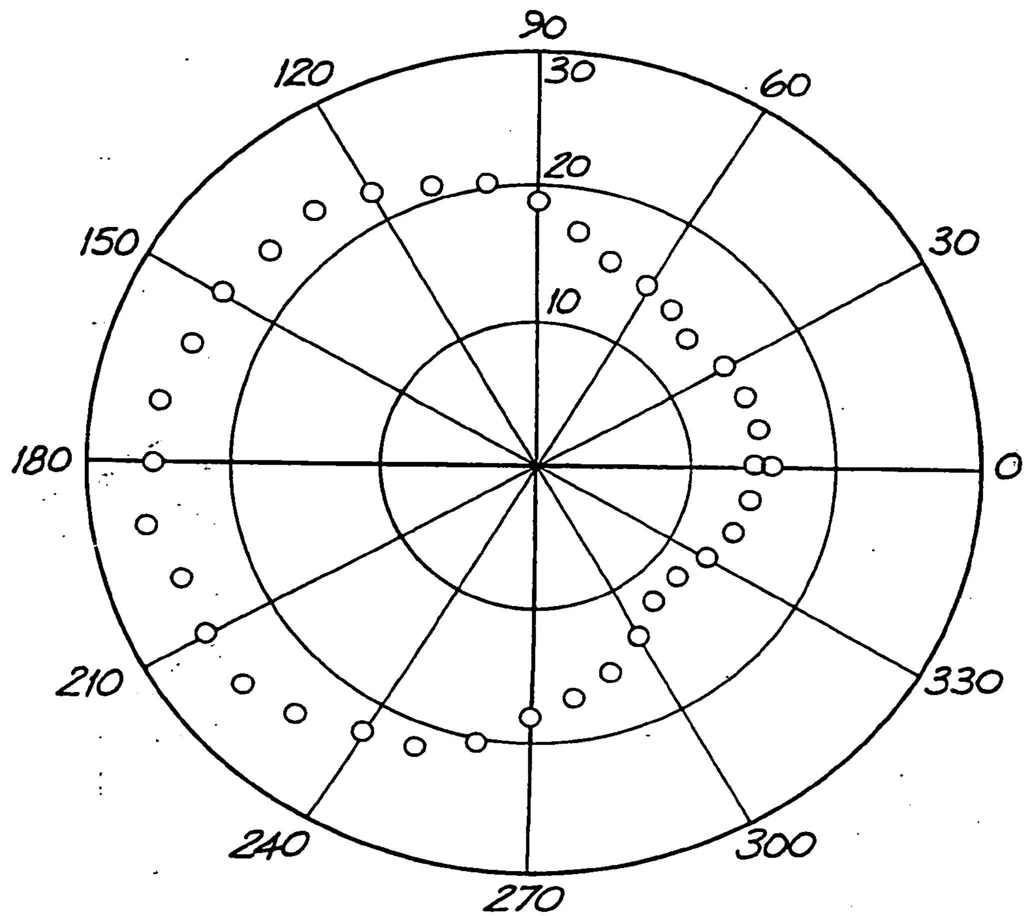


FIG. 4

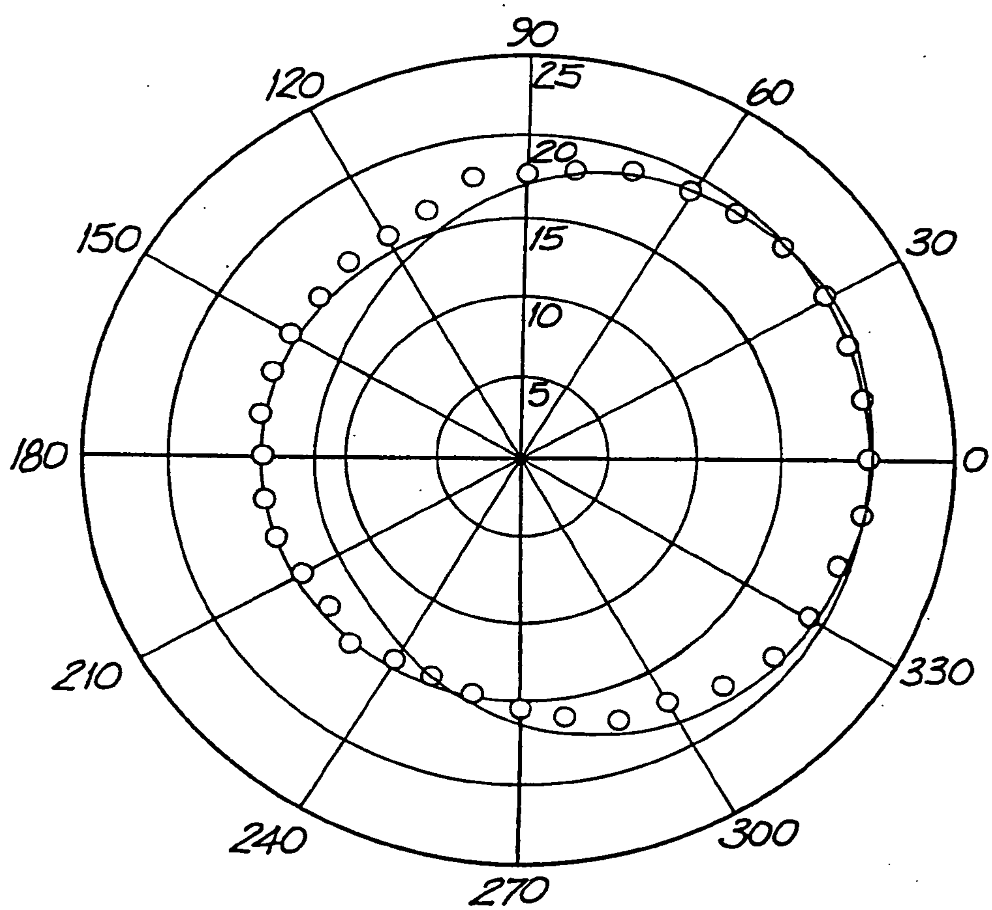


FIG. 5

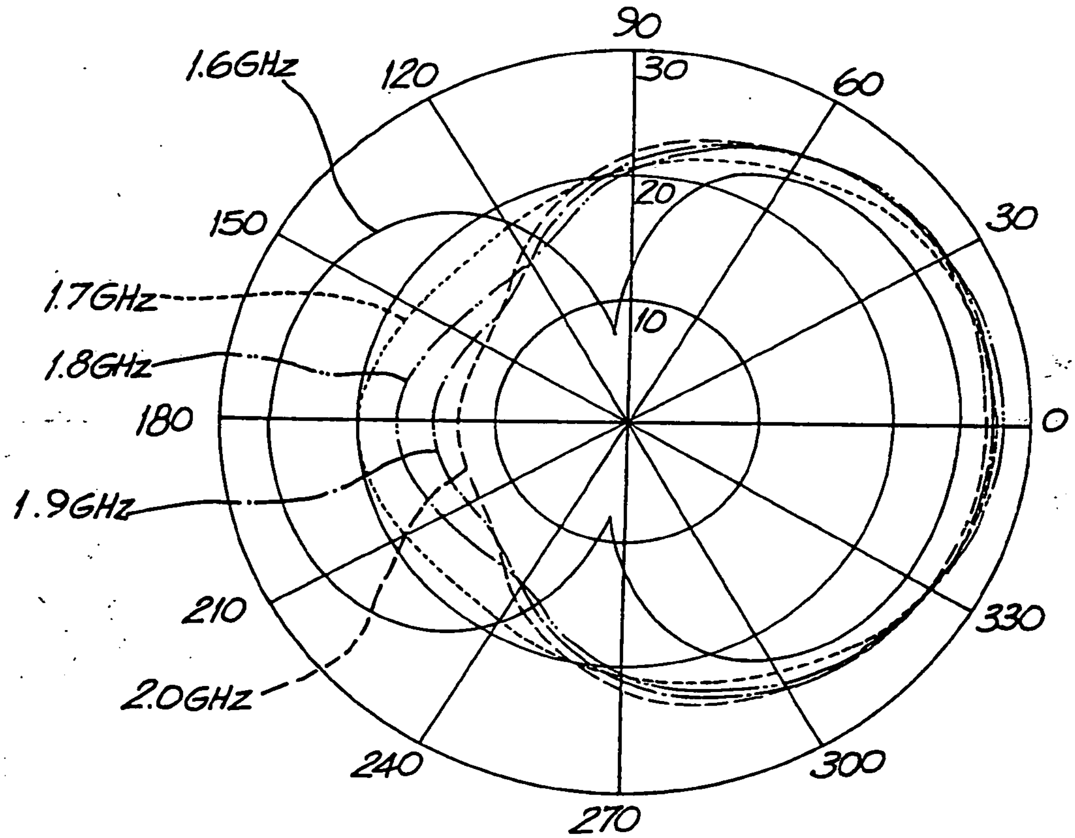

90
30
20
10
120
60
150
30
180
0
210
330
240
300
270
1.6GHz
1.7GHz
1.8GHz
1.9GHz
2.0GHz

FIG. 6

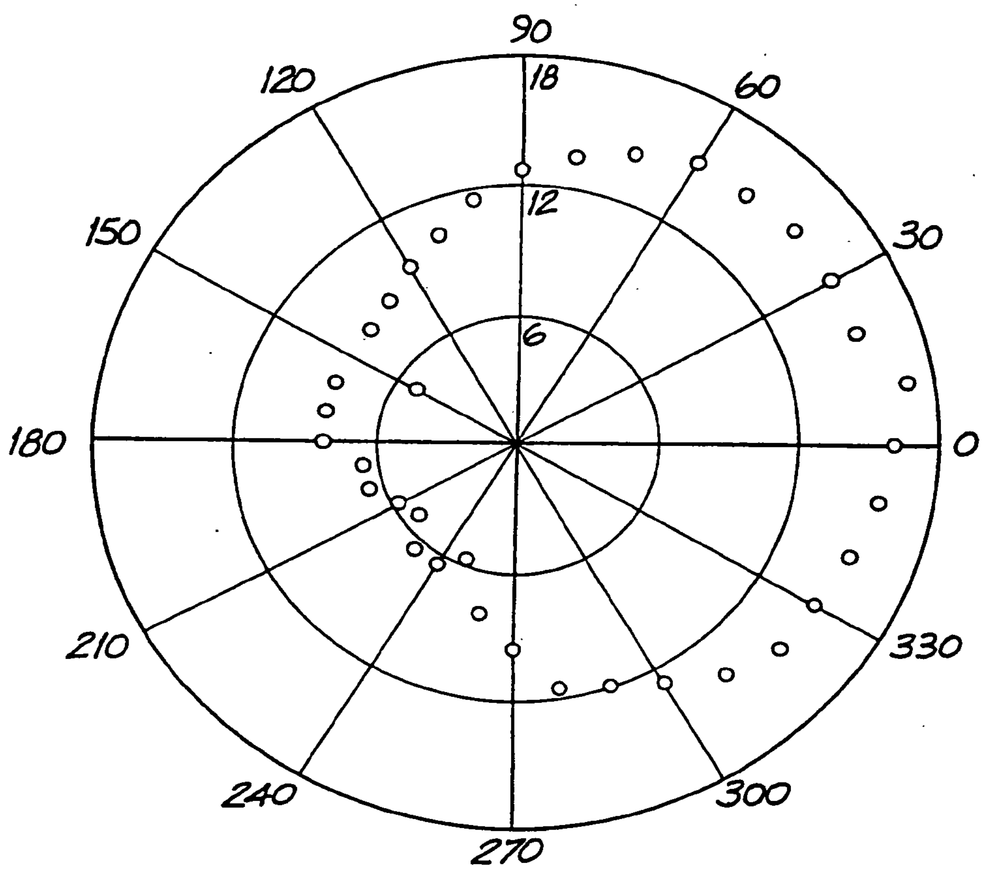


FIG. 7

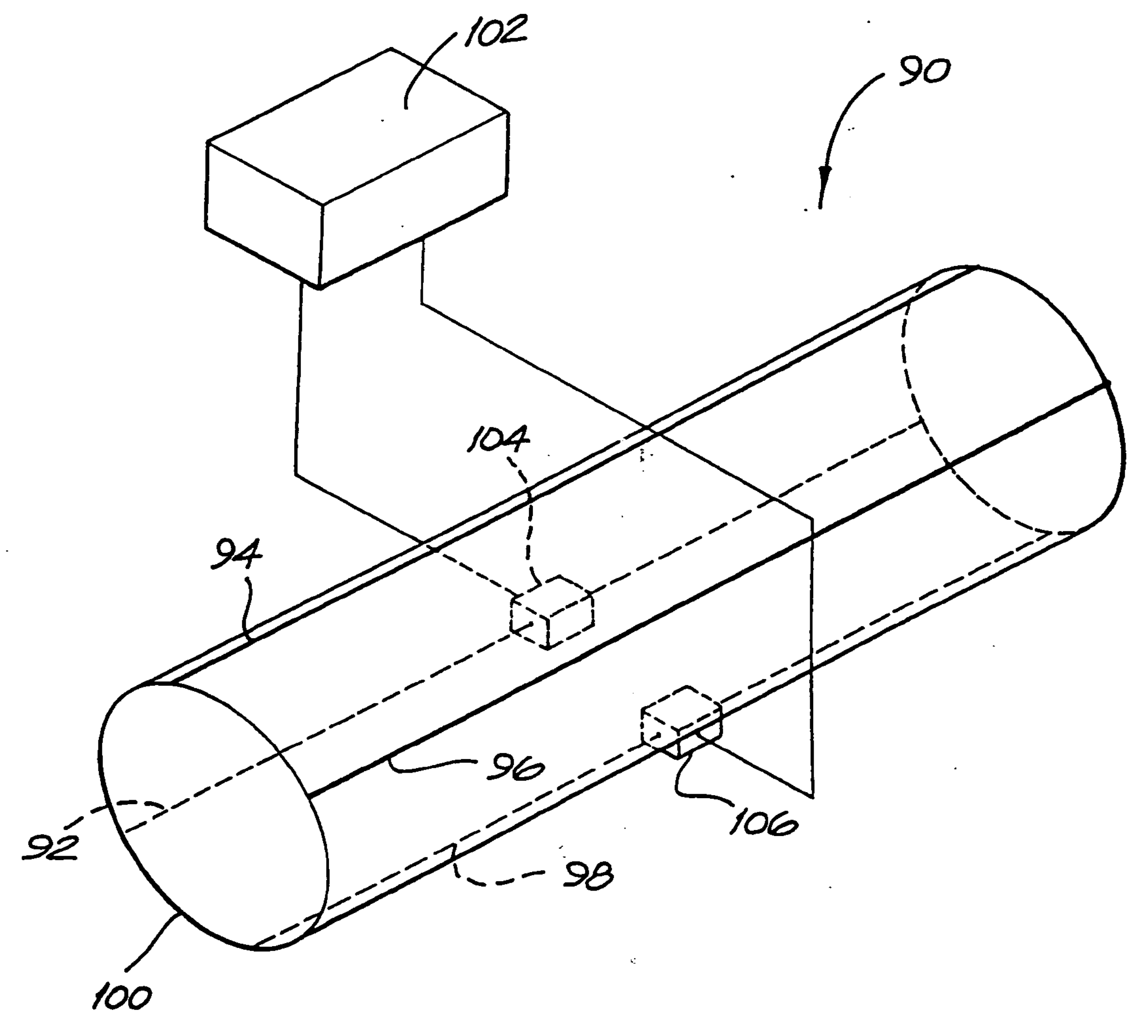


FIG. 8

INTERNATIONAL SEA H REPORT

International application No.
PCT/AU 94/00261

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.[5] H01Q 19/09, 15/14, 3/24, 1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC H01Q 19/09, 15/14, 3/24, 1/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
X	GB,A, 2227370 (KOKUSAL ELECTRIC CO. LTD) 25 July 1990 (25.07.90) Whole document	1,2,4
X	GB,A, 2216726 (KOKUSAL ELECTRIC CO. LTD) 11 October 1989 (11.10.89) Whole document	1,2,4
X	US,A, 4356492 (KALOI) 26 October 1982 (26.10.82) Whole document	5
X	US,A, 4800392 (GARAY et al.) 24 January 1989 (24.01.89) Whole document	6

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 2 September 1994 (02.09.94)	Date of mailing of the international search report 9 Sept 1994 (09.09.94)
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No. 06 2853929	Authorized officer P.P. Gerondal P.P. GERONDAL Telephone No. (06) 2832174

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X,P	EP,A, 0588271 (ALCATEL ITALIA S.p.A.) 23 March 1994 (23.03.94) Whole document	6
X	EP,A, 0214806 (NEC CORPORATION) 18 March 1987 (18.03.87) Figs 1A,2C, page 9 lines 4-8	6
X	US,A, 5075691 (GARAY et al.) 24 December 1991 (24.12.91) Figs 5,6 column 2 line 65 - column 4 line 2	8
X	US,A, 4414550 (TRESSELT) 8 November 1983 (08.11.83) Fig.1 column 2 line 36 - column 3 line 41	9,10
X	US,A, 4379296 (FARRAR et al.) 5 April 1983 (05.04.83) Figs 7A-7C column 5 line 51 - column 6 line 34	9,10
X	US,A, 4367474 (SCHAUBERT et al.) 4 January 1983 (04.01.83) Figs 11-12 column 6 lines 31-58	9,10

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
GB	2227370	JP	2125503	US	5017932		
GB	2216726	JP	1246904	US	5023621		
US	5075691	CA	2063794	EP	484347	JP	4507176
		KR	9402992	WO	9101577		
US	4414550	DE	3279333	EP	72312	JP	58027403
EP	588271	AU	46075/93				
EP	214806	AU	61837/86	CA	1262562	DE	3689455
		JP	62049729	US	4829591		

END OF ANNEX